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RESEARCH ARTICLE

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Studies on the assessment of major nutrients and microbial population of termite mound soil

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ABSTRACT : Assessment of major nutrients of open and closed type of termite mound soil showed that available nitrogen and phosphorus were comparatively higher both in the surface and sub-surface layer than normal soil. Bacterial population was high in the sub-surface soil collected from closed termite mound (75.5×10^5 cfu/g of soil) and open termite mound (65.5×10^5 cfu/g of soil) compared to the normal soil (30.5×10^5 cfu/g of soil). Likewise, Actinomycetes population was also observed to be high in the sub-surface soil of both open and closed type of termite mounds.

KEY WORDS : Termite mound, Soil nutrients, Bacteria, Fungi, Actinomycetes

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INTRODUCTION

Termites are widely distributed throughout the tropical and sub-tropical regions, close to the equator, while fewer species live at higher latitudes. Some termite species extend their range of occurrence to the relatively cool zones of temperate regions (Eggleton, 2000). Termites owe much of their ecological success and consequent economic importance to their highly developed social organisation (Howse, 1970). Termites affect the vegetation in two ways, either by consuming living or dead vegetation or indirectly by modifying the physical and chemical properties of soil enhancing the soil nutrient level and soil water availability which influence the growth of the plants (Lobry de Bruyn and Conacher, 1990).

Termite diversity is tremendous and estimates of damage attributed by termites to structures in North America exceed several billion (US$) annually (Su and Scheffrahn, 2000). Most of the research so far has focused on the assessment of damage inflicted by termites on the one hand and the development of control strategies on the other. Termites play a vital role as a primary consumer and contribute in many ways in the tropical ecosystems (Emerson, 1956). They are involved in increasing soil fertility by disintegrating wood in its many forms and thereby enhance the plant growth. The present studies were, therefore, undertaken to evaluate the status

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of available major nutrients and microbial population of termite mound and normal soil.

EXPERIMENTAL METHODS

Assessment of major nutrients:

50 g of the soil sample were collected from the surface and sub-surface layer (below 15 cm from ground level) of closed type of termite mound, open type of termite mound and adjacent normal soil. A pit of "V" shape is formed and the soil sample is collected using a spade. The soil samples were transferred to a polythene cover and labelled accordingly and take to the laboratory for analysis of major nutrients. Collected soil samples were air-dried (at 20° to 40°C) and crushed with a hammer and passed through a 2 mm stainless steel sieve. The sieved soil samples were assessed for available nitrogen (Alkaline Permanganate Method) (Subbaiah and Asija, 1956), available phosphorus (Olsens method) (Olsen *et al*., 1954) and available potassium (Neutral ammonium acetate method-flame photometry) (Jankowski and Freiser, 1961), respectively.

Assessment of soil microbial population:

10 g of the soil sample were collected for analysis of microbial population as per the same methodology mentioned for the analysis of major nutrients. Nutrient agar media, Rose Bengal agar media and Kenknight media were prepared for the enumeration of bacteria, fungi and actinomycetes of the collected soil samples. Dilution and plating is an inexpensive and relatively simple technology for the enumeration of soil microbes. To calculate the population of bacteria, fungi and actinomycetes, colonies developed on petri dishes were counted and expressed as number of colony forming units (cfu) g^{-1} dry soil. The population density of bacteria, fungi and actinomycetes, were enumerated using serial dilution and plating technique (Parkinson *et al*., 1971).

Statistical analysis:

The data obtained were statistically analysed separately in single factor analysis using AGRES software as suggested by Panse and Sukhatme (1985). The values of critical difference (CD) at 0.05 level and standard error deviation (SEd) are given in the respective tables.

EXPERIMENTAL RESULTS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under the following heads :

Assessment of major nutrients:

Studies on soil nutrient analysis revealed that there was a significant difference in available N among the soils collected from surface and sub-surface layer of open type or closed type of termite mound and adjacent normal soil. Available N was found to be maximum in sub-surface soil of closed type of termite mound (252 kg/ha) (Table 1). The nitrogen content of termite mound soil is higher than that of normal soil (201.2 kg/ha). Nitrogen is a necessary macronutrient for the plant growth and key regulator of ecosystem processes (Jouquet *et al*., 2011). Nitrogen helps make plants greener and helps them grow faster. Nitrogen can be depleted over time by plants, or by being washed away.

The results showed that there was a significant difference in available P among the soils collected for study. Maximum availability of phosphorus (22.3 kg / ha) was witnessed in the sub surface layer of closed termite

Table 1: Status of available major nutrients of termite mound and normal soil

Category	Soil	Major nutrient (kg / ha)		
		Available N	Available P	Available K
Open mound	Surface soil	224.0	12.3	82.0
	Sub-surface soil	246.4	18.6	93.0
Closed mound	Surface soil	229.6	13.6	73.0
	Sub-surface soil	252.0	22.3	85.0
Normal soil	Surface soil	201.6	8.6	115.0
	Sub-surface soil	224.0	12.3	106.0
	S.E.±	1.66	0.99	2.10
	C.D. (P=0.05)	3.62	2.16	4.58

mound. Available phosphorus was found to be 13.6, 12.3 and 8.6 kg/ha in the surface layer of closed termite mound, open termite mound and adjacent normal soil, respectively. Phosphorus is often recommended as a row-applied starter fertilizer which promote root growth, disease resistance, seed and fruit growth and flowering. Available K was observed to be maximum in the surface layer of normal soil (115.0 kg/ha) compared to 82.0 and 73.0 kg / ha in open and closed termite mound, respectively. Potassium is an essential element for plant growth. The main role of potassium is to provide the ionic environment for metabolic processes which regulates various processes including growth regulation. Potassium can facilitate increased root growth, drought resistance and disease resistance.

The termite feed on non-cellular organic material mixed with clay minerals. The gut of termite is modified and adapted for rising of pH, oxygen and hydrogen which are important for soil chemical and physical modifications. Variation in the quantity of available nutrients of termite mound soil and normal soil were as a result of organic matter and deposition of faeces and saliva by the termites which enrich the soil with N and P. During this process they can breakdown the litter into minute particles, enhancing the fungal and bacterial action, favouring the decomposition of organic matter.

The organic material which pass through the digestive tract gets subjected to various chemical and biological processes such as organic matter, as well as its humification degree and complication with metal ions (Ackerman *et al*., 2007). Thus, the higher values of above parameters in the termite soil compared to adjacent normal soil are attributed to termite behaviour of ingesting soil organic matter and returning it as faecal matter, in which the organic matter is physically and chemically protected, forming stable aggregates. The acceleration of organic matter decomposition due to termite action can further increase the aggregate stability and soil porosity, which can enhance water retention (Bignell and Eggleton, 2000). In the oligotrophic environment, the increase in available phosphorous content in termite mound soil could be due to its organic nature, compared to adjacent normal soil. Mound soils generally have high clay content, enhancing water storage capacity. Mostly, soils with low water retention capacity are common, and, hence, when mound soil is spread on these soils it would help in enhancing the soil moisture content and in turn improved crop growth.

The soil particles, they undergo major modifications during gut transit when resistant organic compounds are, in turn, submitted to highly alkaline, aerobic, and anoxic conditions and to putative microbial degradation (Noirot, 1969). This transit results in a major change in the soil organic matter quality (humic acid hydrolysis, protein degradation and distribution) due to the creation of newly formed stable organo-mineral complex. These complex excreted as faeces contribute to the formation of stable micro- and macro-aggregates in the termite mound .

The specificity of the mound does not seem to arise from selection of a specific soil organic matter, as the composition of the organic matter contents of the gut does not differ from that of the surrounding soil. Sub surface layer had a higher density probably owing to its higher humidity and nitrogen content. Termites also enhance the decomposition of surface-applied organic materials stimulating nutrient release, which can then be used by growing plants. These results confirm that termites are not only pests, but can also be highly beneficial biological agents whose bio-turbating and decomposing activities can be managed indirectly (with

Table 2 : Assessment of microbial population in termite mound and normal soil

Category	Soil	Bacteria ($\times 10^5$ cfu/g of soil)	Fungi ($\times 10^4$ cfu/g of soil)	Actinomycetes ($\times 10^3$ cfu/g of soil)
Open mound	Surface soil	32.0	7.0	88.0
	Sub-surface soil	65.5	12.0	61.5
Closed mound	Surface soil	43.0	6.0	45.5
	Sub-surface soil	75.5	7.0	62.5
Normal soil	Surface soil	48.5	10.0	58.0
	Sub-surface soil	30.5	18.0	29.0
	S.E.±	1.26	1.41	1.37
	C.D. (P=0.05)	2.76	3.08	2.99

organic matter) to enhance primary production. Termites mediated processes to enhance soil restoration and agricultural production in the farming system (Dhembare, 2013).

Our study also showed that mound soils have high level of phosphorus which is useful to better crop development. Plants also take up nutrients very easily from termite mound soil. Termite soil could also prove as an alternative to local farmers who cannot afford to buy expensive inorganic fertilizers. If the density of mound is low, mound soil could be collected, crushed and mixed with top soil for taking up small farming activities. The possibility of developing adequate management techniques should be carefully studied before propagating the use of nest matter for crop production.

Assessment of microbial population:

Bacterial population was high in the sub surface soil of closed mound (75.5×10^5 cfu/g of soil) followed by the sub surface soil of open mound (65.5×10^5 cfu/g of soil) (Table 2). The bacterial count observed in the surface soil samples of open mound, closed mound and normal soil, were 32.0×10^5, 43.0×10^5 and 48.5×10^5 cfu/g of soil, respectively. Fungal population was found to be very low in the surface soil of closed mound (6.0×10^4 cfu/g of soil) and higher fungal count was witnessed in the normal soil collected from the sub-surface layer (18.0×10^4 cfu/g of soil). Comparison of the various soil samples revealed that actinomycetes population was high in the surface soil of open termite mound (88.0×10^3 cfu/g of soil) and low in the normal soil collected from the sub-surface layer (29.0×10^3 cfu/g of soil).

Bacterial species involving *Bacillus* sp. and *Pseudomonas* sp., fungal colony involving *Rhizopus, Mucor, Aspergillus, Penicillium* sp. were observed in the soil sample collected from the surface and sub-surface layer of open mound, closed mound and adjacent normal soil. Actinomycetes, namely, *Nocardia* sp. and *Streptomyces* sp. were also recorded. High atmospheric nitrogen deposition could be a prime factor for low fungal count. *Aspergillus, Rhizopus, Mucor* and *Penicillium* were the abundant genera in the sites. It was noticed that plant residues, added organic matter, vegetation, plant species composition and soil mineral nutrients altered the microbial population in soil adjacent to the termite mounds. Dominance of the genus *Rhizopus* in the present studied soils may be due to their greater rate of spore production and dispersal and partly due to their resistance over extreme environmental conditions.

Classen *et al*. (2007) pointed out that during hot summer months, the sub-surface layer of soil occasionally harbour more fungal populations caused by temperature and moisture regimes than the topsoil layer. Higher counts of bacterial and fungal population in sub surface soils of the mounds of termites may be attributed to the dense growth of plants and greater availability of nutrients on account of greater accumulation of litter and may also be due to secretions, saliva or faeces.

Termite mounds have very specific properties arising from the combination of materials of two distinct origins, faeces and soil (Wood and Johnson, 1986). This creates an increased richness in clay (5 times more), minerals (2 to 3 times more P and Ca; and upto 50 times more NH_4 and organic matter (5 to 7 times more C and N) with respect to neighbouring soil. The environment for micro-organisms derived from soil and faeces is modified not just by an increase in available organic compounds but also by a change in their qualities (C/N, humic acid/sugar content and their availability by the formation of stable clay-humus complex) **(**Batjes, 1996). This richness in organic matter appears to be the reason for the increase in microbial density in termite mounds (3 to 24 times). However, this increase in density is not accompanied by a significant increase in bacterial activity (mineralization) with respect to neighbouring soil.

Differences in temperature, rainfall, or humidity may also affect soil microbiotas surrounding termite mounds (Jouquet *et al*., 2002). Compared to the surrounding soil, these mounds are characterized by higher humidity and higher concentrations of organic matter and cations leading to an increase in the microbial biomass. The termite mound had a higher density of bacteria than the surrounding soil. This increase might be attributed to the significant improvement of the organic matter content in the mound compared to the normal soil.

The specificity of the microbial community associated with the mounds is more likely to be due to the significant modification of the soil subjected to termite activity (Jouquet *et al*., 2005). The soil particles, they undergo major modifications during gut transit when resistant organic compounds are, in turn, submitted to highly alkaline, aerobic and anoxic conditions and to putative microbial degradation. This transit results in a major change in the quality of soil organic matter (humic acid hydrolysis, protein degradation and soil organic matter distribution due to the creation of newly formed stable organo-mineral complex).

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